Species Status Assessment

Class: **Bivalvia**
Family: **Unionidae**
Scientific Name: ***Alasmidonta viridis***
Common Name: **Slippershell mussel**

Species synopsis:

Alasmidonta viridis belongs to the subfamily Unioninae and the tribe Anodontini, which includes 16 extant and 1 likely extirpated New York species of the genera Alasmidonta, Anodonta, Anodontoides, Lasmigona, Pyganodon, Simpsonaias, Strophitus, and Utterbackia (Haag 2012, Graf and Cummings 2011). *A. viridis* is a member of the genus *Alasmidonta,* named for its lack of lateral teeth. The species name *viridis* refers to the green color of the periostracum (Watters et al. 2009).

In New York, *A. viridis* is found in three Erie basin waterbodies (Mahar and Landry 2012, NY Natural Heritage Program 2013). Although rare in New York, this edge of range species is considered "Apparently Secure" throughout its range. It occupies a wide range of habitats, from small streams to large rivers (Strayer and Jirka 1997), and it is typically found living in a substrate of sand and fine gravel.

In North America, approximately ⅔ to ¾ of native mussel species are extinct, listed as endangered or threatened, or are in need of conservation status (Williams *et al.* 1993; Stein *et al.*2000). While *A. viridis* population trends in New York are unknown, it is assumed that they too are declining, due to a myriad of environmental stressors.

Status

a. Current and Legal Protected Status

i. **Federal**____None_______________________________**Candidate?** ___No_______

ii. **New York** ____Species of Greatest Conservation Need______________________

b. Natural Heritage Program Rank

i. **Global** _____G4G5 – Apparently Secure / Secure______________________

ii. **New York** S1S2 – Critically imperiled / Imperiled **Tracked by NYNHP?** _Yes

Other Rank:
American Fisheries Society Status: Special Concern (1993)

Status Discussion:
This species is widespread in the eastern U.S. and is distributed from Lake Huron, St. Clair and Erie, and upper Mississippi River system, south to Ohio, Cumberland, and Tennessee River systems. Although intolerant of impoundment, it is considered stable throughout most of its range (NatureServe 2013).

II. Abundance and Distribution Trends

a. North America

i. **Abundance**

_____ declining _____increasing ____X__stable _____unknown

ii. **Distribution:**

_____ declining _____increasing ___X___stable _____unknown

Time frame considered: ____

b. Regional

i. Abundance

____ declining ____increasing __X___stable _____unknown

ii. Distribution:

____ declining ____increasing __X___stable ______unknown

Regional Unit Considered:_______Midwest________________________________
Time Frame Considered: ____

c. Adjacent States and Provinces

CONNECTICUT Not Present __X____ No data _______

MASSACHUSETTS Not Present ___X___ No data _______

NEW JERSEY Not Present __X___ No data _______

ONTARIO Not Present _________ No data _______

i. Abundance

____ declining ____increasing ______stable ___X__unknown

ii. Distribution:

____ declining ____increasing ______stable ___X__unknown

Time frame considered: __________2003-2013______________________________
Listing Status: ____S3____

Rare species not often encountered (Morris, personal communication).

PENNSYLVANIA Not Present ___X___ No data _______

QUEBEC **Not Present** __X__ **No data** ____

VERMONT **Not Present** __X__ **No data** ____

d. NEW YORK **No data** ____

i. Abundance

__X__ **declining** ____**increasing** ____**stable** ____**unknown**

ii. Distribution:

__X__ **declining** ____**increasing** ____**stable** ____**unknown**

Time frame considered: ____

Monitoring in New York.

As part of a State Wildlife Grant, NYSDEC Region 8 Fisheries and Wildlife staff is conducting a baseline survey of tributaries in central and western New York for native freshwater mussels 2009 – 2017.

Trends Discussion:

Trends for New York populations are difficult to determine as most historic data comes from opportunistic naturalist collections, as opposed to more comprehensive baseline surveys. For example, mussels were documented for the first time in 50 of the 106 streams surveyed to date by the Southern Lake Ontario mussel inventory project (Mahar and Landry 2013). This is because many of these streams had never before been surveyed for mussels, not because mussel distribution has dramatically increased. In North America, approximately 2/3 to ¾ of native mussel species are extinct, listed as endangered or threatened, or are in need of conservation status (Williams *et al.* 1993, Stein *et al.*2000). Based on New York's Natural Heritage S-rank, sparse historical data, and the plight of North America's freshwater mussels, it is assumed that trends are declining due to a myriad of environmental stressors.

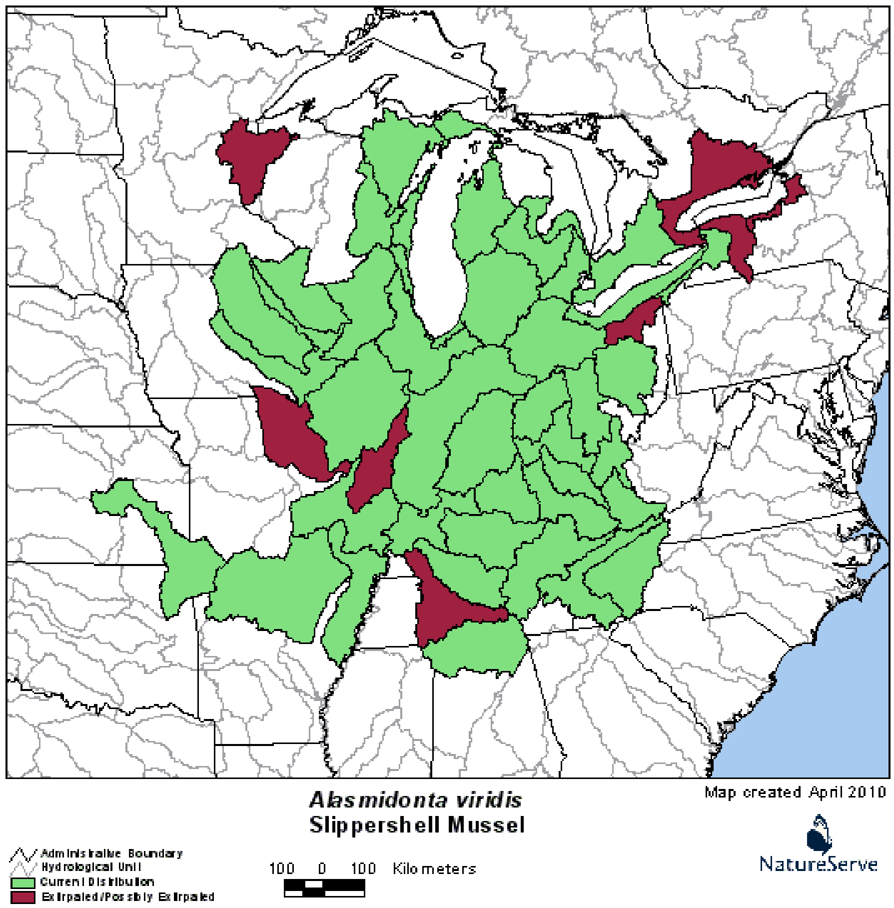

Figure 1. Range wide distribution of *A. viridis* in North American (NatureServe 2013).

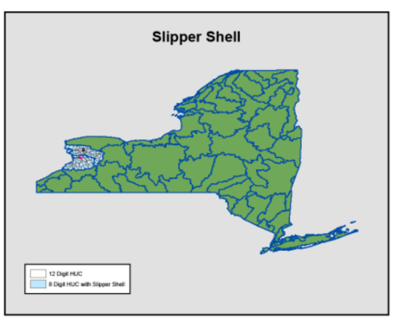

Figure 2. Post 1970 distribution of *A. viridis* in New York (Mahar and Landry 2013, Harman and Lord 2010, The Nature Conservancy 2009, New York Natural Heritage Program 2013, White et al. 2011).

III. New York Rarity, if known:

Historic	# of Animals	# of Occurrences	% of State
prior to 1970	_unknown__	_~5 waterbodies_	3 of 56 HUC 8 watersheds
prior to 1980	________	________	________
prior to 1990	________	________	________

Details of historic occurrence:

A. viridis has historically been known from the Buffalo River basin, Niagara River, Tonawanda Creek, and the lower Genesee basin (Strayer and Jirka 1997). Mud Creek in Monroe County was the presumed location of the Genesee basin occurrence (Strayer and Jirka 1997), however, I was unable to locate a Mud Creek in Monroe County. There is, however, a known mussel stream named Mud Creek which is a tributary of Tonawanda Creek. It may be worth surveying for *A. viridis* in this tributary.

Current	# of Animals	# of Occurrences	% of State
	__Unknown – few, if any_	_3 waterbodies__	_2 of 56 HUC 8 watersheds_

Details of current occurrence:

Post 1970, *A. virdis* has been found in 3 waterbodies in New York State (Figure 2). In the Erie basin, it has been found in Tonawanda Creek (Strayer and Jirka 1997), and as fresh shells in Beeman Creek, a Tonawanda Creek tributary (Mahar and Landry 2013), and Buffalo Creek (NY Natural Heritage Program 2013). In Beeman Creek, 88 shells were found (Mahar and Landry 2013), indicating that a large population still exists in this waterbody. No recent occurrences from the Niagara River or Monroe County have been reported.

New York's Contribution to Species North American Range:

% of NA Range in New York	Classification of New York Range
____ 100 (endemic)	____ Core
____ 76-99	__X__ Peripheral
____ 51-75	____ Disjunct
____ 26-50	Distance to core population:
__X__ 1-25	___350 miles________

IV. Primary Habitat or Community Type:

1. Medium River; Low Gradient; Assume Moderately Buffered (Size 3+ rivers); Warm
2. Headwater/Creek; Low-Moderate Gradient; Moderately Buffered, Neutral; Transitional Cool
3. Small River; Moderate-High Gradient; Moderately Buffered, Neutral; Transitional Cool

Habitat or Community Type Trend in New York:

____ Declining ____Stable ____ Increasing __X__Unknown

Time frame of decline/increase: ______________________________

Habitat Specialist? ___X___ Yes _______ No

Indicator Species? ___X___ Yes _______ No

Habitat Discussion:

Throughout its range, this species is typically found in headwater streams but also may occur downstream (NatureServe 2013). In New York, it occupies a wide range of habitats, from small streams to large rivers. In fact, the largest historical collections of this species in New York have come from the Niagara River (Strayer and Jirka 1997). It is found in high to moderate gradient streams, and while it may be found in riffles, it is typically found living in a substrate of sand and fine gravel. In stretches where there is a continuous current it will thrive in a mud and sand bottom among roots of aquatic vegetation (Cummings and Mayer 1992, McMurray et al. 2012, Metcalf-Smith et al. 2005, NatureServe 2013). It is a small sized species that may burrow out of sight in sand or sandy mud, so may be easily overlooked.

It is thought to be a moderate habitat specialist (NatureServe 2013) and is not found in impounded waters (Watters 1995).

V. New York Species Demographics and Life History

__X__ **Breeder in New York**

  __X__ **Summer Resident**

  __X__ **Winter Resident**

  ____ **Anadromous**

____ **Non-breeder in New York**

  ____ **Summer Resident**

  ____ **Winter Resident**

  ____ **Catadromous**

____ **Migratory only**

____ **Unknown**

Species Demographics and Life History Discussion:

Upstream males release sperm into the water. Females downstream take up the sperm with incoming water. Fertilization success may be related to population density, with a threshold density required for any reproductive success to occur. Eggs are fertilized within the female. Like nearly all North American mussels, *A. viridis* must parasitize an often specific vertebrate host to complete its life cycle. It is suspected that some mussel populations are not recruiting because their hosts no longer occur with them. Once released by the female, glochidia must acquire a suitable host or die, usually within 24-48 hours. After attaching to a suitable host, glochidia encyst, usually at the fish's gills or fins and receive nutrition and dispersal. Once the glochidia metamorphose into juveniles, they drop from the host. If they land in suitable habitat, they will burrow into the substrate, where they may remain for several years (Watters et al. 2009).

In the adult form, freshwater mussels are basically sessile; movement is limited to a few meters of the lake or river bottom. The only time that significant dispersal can take place is during the parasitic phase. Infected host fishes can transport the larval unionids into new habitats, and can replenish depleted populations with new individuals. Dispersal is particularly important for genetic exchange between populations. Dispersal is likely to be a slow process for mussels which use resident fishes with limited home ranges as their hosts (COSEWIC as cited in NatureServe 2013).

This species has a periodic life history strategy, characterized by moderate to high growth rate, low to intermediate life span, age at maturity, and fecundity, but generally smaller body size than opportunistic species. Most species are long-term brooders. This life history strategy is considered an adaptation to allow species to persist in unproductive habitats or habitats that are subject to large-scale, cylindrical environmental variation or stress (Haag 2012).

A. viridis is probably bradytictic, with glochidia overwintering on in the female. Gravid females are present in September. Glochidia have been shown to transform on banded sculpin (*Cottus carolinae*) (Zale and Neves 1982). Other reported potential hosts include Johnny darter (*Etheostoma nigrum*) and mottled sculpin (*Cottus bairdi*) (Strayer and Jirka 1997, NatureServe 2013). Individuals typically live for less than 10 years (Watters et al. 2009).

VI. Threats:

Agricultural Runoff

New York's populations of *A. viridis* are found in the Tonawanda Creek and Buffalo River watersheds. These are highly agricultural areas, with fields bordering the streams (New York State Landcover 2010). Aquatic habitats lacking vegetated buffers of adequate width are threatened by runoff from urban areas, roads, lawns, and agricultural land (Gillis 2012). If best management practices are not closely adhered to, mussel habitat adjacent to wood harvest or agricultural land is subjected to pesticide, fertilizer, and silt/sediment runoff. During recent mussel surveys in western and central New York, it has been documented that sufficient vegetated riparian buffers are often lacking along known mussel streams (Mahar and Landry 2013), indicating that runoff is a major threat to resident mussel populations.

The presence of pesticides and fertilizers in our rural watersheds is nearly ubiquitous (Haag 2012). And because pesticides and their associated surfactants adsorb onto sediment particles, sedimentation may act as a vector for their transport into the aquatic system (Haag 2012). Mussels are more sensitive to pesticides than many other animals (Watters et al. 2009). Although effects of pesticides are species-specific, sub-lethal levels of PCBs, DDT, malathion, and other compounds inhibit respiratory mussel efficiency and accumulate in the tissues. Atrazine and permethrin at sublethal concentrations reduced juvenile growth (Bringolf et al. 2007a, 2007b) and environmental levels of atrazine altered mussel movement and aggregation behavior (Flynn and Spellman 2009). Pesticides can affect mussels in many ways, but the full range of long-term effects remains unknown (Haag 2012).

Fertilizer runoff is also a concern. High inputs of nitrogen from fertilizers can cause increases in ammonia in the water and the substrate, leading to direct toxicity for a wide range of mussel species. Mussels, especially in their early life stages, are more sensitive to un-ionized ammonia than other organisms, and high sensitivity is seen across a range of species and life histories (Haag 2012). In addition, ammonia adsorbs to sediment particles, resulting in higher nitrogen concentrations in the substrate than in the overlying water. The nitrogen present in the interstitial spaces in the substrate is thought to result in juvenile mortality and to prevent recruitment by some mussel species (Strayer and Malcom 2012). Studies have suggested decreasing sediment loads entering aquatic systems as the best way to decrease the impact of numerous stressors for mussels in general (Roley et al. 2012).

Runoff from Developed Land

In addition to agricultural fields, roads and residential structures are located adjacent to Tonawanda, Beeman, and Buffalo Creeks (New York State Landcover 2010). These developed areas are likely sources of non-point-source runoff containing metals and road salts. Mussels are particularly sensitive to heavy metals, more so than many other animals used in toxicological tests (Keller and Zam 1991). Low levels of metals may interfere with the ability of glochidia to attach to the host (Huebner and Pynnonen 1992), suggesting that U.S. EPA ambient water quality criteria may not adequately protect mussels from toxic metals (Wang et al. 2011). In addition, increases in salinity from the runoff of salt used for clearing roads in winter may be lethal to glochidia and juvenile mussels (Keller and Zam 1991, Liqouri and Insler 1985, Pandolfo et al. 2012). Based on these studies, the U.S. EPA's ambient water quality criterion for acute chloride exposures may not be protective of all freshwater mussels (Pandolfo et al. 2012).

Habitat Modification

Ecosystem modifications, such as in-stream work associated with bridge replacements or gravel mining kill mussels and destroy their habitat. For example, dredging for vegetation removal has been shown to remove up to 23% of mussels in spoils (Aldridge 2000). Further evidence for disruption was provided by mussel surveys adjacent to approximately 20 river miles of Conewango Creek that had been channelized and straightened in the first half of the 20th century. The resulting "dredge" had no riffle or run habitat and sites just below and above this channelized section contained few or no mussels (The Nature Conservancy 2009). Although limited in geographic scope these habitat modification activities have long term impacts on mussels and their distribution (Aldridge 2000). Although limited in geographic scope, their impact on a species with limited distribution would be devastating.

Water Temperature Changes

The NatureServe Climate Change Vulnerability Index has been used in several states to help identify species that are particularly vulnerable to the effects of climate change. While *A. viridis* vulnerability was not evaluated for New York, the populations within Michigan are ranked as "extremely vulnerable" to climate change (Hoving et al. 2013). Gailbreth et al. (2010) showed how regional climate patterns coupled with changing local water regimes and management strategies have shifted mussel populations from thermally sensitive species, such as *A. viridis*, to thermally tolerant species.

Impoundments

It has been noted that *A. viridis* is intolerant of impoundments (NatureServe 2013). While it is highly unlikely that new impoundments will be constructed in this area, culverts and bridge crossings should be properly maintained so that water does not collect upstream of the structures, due to debris build up or an inadequate sized instillation. In addition, improperly sized and poorly installed or poorly maintained culverts have impacts similar to dams in that they fragment habitat, preventing the movement by host fish, and effectively isolating mussel populations. And because culverts are located at nearly every road-stream intersection, there is the potential for landscape level fragmentation of mussel habitat.

Across its range, impoundments likely contributed to the reduced distribution of mussels that we see today. Vaughn and Taylor (1999) observed a mussel extinction gradient with a gradual, linear increase in mussel species richness and abundance with increasing distance downstream from impoundments. Species and their hosts that require shallow, oxygenated, fast-flowing water quickly are eliminated. Continuously cold water from both increased water depth upstream of the dam and dam discharges downstream of the dam may prevent reproduction. Impoundment increases silt load and eutrophication, resulting in changes in the fish fauna, and therefore the availability of hosts. Dams represent distributional barriers to fish hosts, and therefore to the mussels themselves. The zoogeographic patterns of several species suggest a dam-limited range. Dams also act as sediment traps, often having many feet of silt and debris caught on their upstream side. These areas generally are without mussels. Below the dam, the tailwaters often have dense mussel beds, as these reaches are the only areas left that still have oxygenated, fast moving water. This is exemplified by the distribution of beds in the lower Muskingum River, Ohio (Stansbery and King 1983, ESI 1993c).

Are there regulatory mechanisms that protect the species or its habitat in New York?

______ No _____ Unknown

__X____ Yes

Mussel habitats receive some generic protection under several New York State regulations (NYCRR) promulgated under the authority of the New York Environmental Conservation Law (ECL), specifically Part 608 of the NYCRR: Use and Protection of Waters, and Part 617 of the NYCRR: State Environmental Quality Review (SEQR). Part 608 provides protection of some mussel habitats by regulating and requiring environmental review of the modification or disturbance of any "protected stream", its bed or bank, and removal of sand, gravel or other material from its bed or banks (608.2 Disturbance of Protected Streams). This does not provide adequate protection of mussels and their habitats as it only protects streams or particular portions of a streams for which there has been adopted by NYSDEC or any of its predecessors any of the following classifications or standards: AA, AA(t), A, A(t), B, B(t) C(t), or Streams designated (t)(trout) also include those more specifically designated (ts)(trout spawning). Mussel habitats may also receive some additional protections as the construction, repair, breach or removals of dams, and the excavation and placement of fill in navigable waters are subject to regulation and environmental review under Part 608, 608.3 and 608.5 respectively. Under part 608, projects requiring a permit can be conditioned by NYSDEC to include best management practices, such as sediment and erosion protections. Through the review process, these projects can also be modified to reduce impacts in order to meet permit issuance standards.

Under Part 608, protection of unlisted species of mussels is general and relatively limited. More importantly, Class C and D waters with mussels do not receive protection under these regulations. A significant portion of the New York's mussel resources occur within Class C and D waters. An additional but not insignificant gap in protection occurs because agricultural activities consisting of the crossing and re-crossing of a protected stream by livestock or wheeled farming equipment normally used for traditional agricultural purposes or of withdrawing irrigation water in a manner which does not otherwise alter the stream, are exempt from these regulations and environmental review.

Water quality certifications required by Section 401 of the Federal Water Pollution Control Act, Title 33 United States Code 1341(see subdivision (c) of this Section) may provide protection for freshwater mussels and their habitats from some activities that would potentially have adverse impacts by regulating construction or operation of facilities that may result in any discharge into navigable waters. Water quality certifcations set water quality-related effluent limitations, water quality standards, thermal discharge criteria, effluent prohibitions and pretreatment standards for projects on navigable waters.

The State Environmental Quality Review (SEQR, Part 617 NYCRR) may also protect mussels and their habitats by requiring the consideration of environmental factors into the existing planning, review and decision-making processes of state, regional and local government agencies for activities that require discretionary approval. SEQR requires the preparation of an Environmental Impact Statement, including an alternatives analysis, for those activities that may result in a substantial adverse change in ground or surface water quality; a substantial increase in potential for erosion, flooding, leaching or drainage problems; the removal or destruction of large quantities of vegetation or fauna; substantial interference with the movement of any resident or migratory fish or wildlife species; impacts on a significant habitat area; substantial adverse impacts on a threatened or endangered species of animal or plant, or the habitat of such a species; other significant adverse impacts to natural resources; or, a substantial change in the use, or intensity of use, of land including agricultural, open space or recreational resources, or in its capacity to support existing uses.

New York State has numerous laws and regulations that both directly or indirectly protect waters of the state (mussel habitats) including regulations governing direct discharges to surface and groundwater, storm water, agricultural activities, pesticides, flood control, and dams. Without these regulations, mussels would certainly be in worse shape; however, most of these generic protections are not adequate in scope or specific enough to mussel threats to protect the mussel resources of New York State.

Describe knowledge of management/conservation actions that are needed for recovery/conservation, or to eliminate, minimize, or compensate for the identified threats:

- Priority conservation efforts for this species should focus on, but not be limited to, Beeman Creek (Mahar and Landry 2013).

- Modify marine mussel regulations or the definition of protected wildlife in NYCRR to clarify that freshwater mussels are protected under ECL. Current regulations could be interpreted that freshwater mussels may only be protected as shellfish without a season within the Marine District.

- Through landowner incentive programs or regulation, riparian buffers, particularly those that also provide shade, should be added/maintained/widened, along agricultural fields, subdivisions, and along major roads to decrease the levels of nitrogen, pesticides, sediment, heavy metals, and salts from entering these aquatic systems, as well as to moderate water temperature.

- Require all state agencies to maintain appropriate vegetative buffers along streams, rivers and lakes on state-owned or state managed properties.

- Develop and implement a comprehensive monitoring strategy that identifies protocols, including locations and specific intervals, for regular monitoring of known mussel populations to detect assess trends and detect dangerous declines.

- Mussel sensitivity to particular pollutants should be considered or addressed in the regulation of wastewater and stormwater discharges to groundwater and surface waters, State Pollutant Discharge Elimination Systems (SPDES). This should be reflected in effluent limitations for discharges, including discharges from P/C/I facilities (Private/Commercial/Industrial), CAFO facilities (Concentrated Animal Feeding Operations), High Volume Hydraulic Fracturing Discharges, and Wastewater treatment plants, etc. Discharges whose receiving waters have mussels, particularly those with known populations of mussels listed as Endangered, Threatened, Special concern or SGCN, should be carefully reviewed for potential impacts to mussels. For example, deleterious levels of ammonia (a component of many types of discharges) and molluscicides (a commonly used water treatment chemical in discharged water) should not be permitted.

- Establish a protocol whereas DEC staff work closely with state and local highway departments to reduce impacts to native mussels during maintenance and construction projects.

- Replace culverts that disrupt aquatic habitat connectivity to allow for passage of small fish species.

- Within the Great Lakes and Champlain watersheds, lamprey control efforts should consider specific, potentially adverse, impacts to native freshwater mussels when determining methods, including selection of lampricide formulations and concentrations. Lampricide treatment managers should use caution when using the combination of TFM and niclosamide in streams with known mussel populations and every effort should be made to maintain lampricide concentrations at or near the MLC for sea lamprey to minimize the risk to this important faunal group (Boogaard 2006).

- NYSDEC should consider sensitivity of freshwater mussels to specific pollutants in the establishment and setting of water quality standards and TMDLs for waters containing freshwater mussels. A Total Maximum Daily Load (TMDL) specifies the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. TMDLs account for all contributing sources (e.g. point and nonpoint sources, and natural background levels), seasonal variations in the pollutant load, and incorporate a margin of safety that accounts for unknown or unexpected sources of the pollutant. In essence, a TMDL defines the capacity of the waterbody to absorb a pollutant and still meet water quality standards. The Clean Water Act requires states to identify waterbodies that do not meet water quality standards after application of technology-based effluent limitations. For these "impaired waters," states must consider the development of alternative strategies, including TMDLs, for reducing the pollutants responsible for the failure to meet water quality standards.

The Comprehensive Wildlife Conservation Strategy (NYSDEC 2006) includes recommendations for the following actions for freshwater mussels:

Habitat management:

- Manage areas of important mussel populations by controlling degradation factors (e.g.. Controlling livestock access, point source or non-point source pollution, flow alteration, etc.)
- Develop methods to improve and restore freshwater bivalve habitat.

Habitat research:

- Conduct research to determine habitat parameters necessary for good populations of each species of species-at-risk listed mussels.
- Research flow requirements of freshwater bivalves and model the effects of flow changes both in volume and timing.

- Research all parameters of mussel habitat requirements including temperature, substrate, fish, flow, food, etc.

Habitat restoration:

- Restore degraded habitat areas to allow for recolonization or reintroduction of listed mussels.

Invasive species control:

- Develop a monitoring/control plan that includes measures to detect invasive species problematic to freshwater bivalves in all New York watersheds and actions that will be taken to control them before they become threats.
- Conduct research on control of exotic bivalve species that compete with native mussels and exotic crustaceans or fish which may prey on them.

Life history research:

- Research effects of pesticides and other chemicals, including ammonia, on all life stages of freshwater bivalves: sperm/egg, glochidia, larva, adults.
- Research potential interbreeding between *Alasmidonta varicosa* and *Alasmidonta marginata* and, if occurring, evaluate the potential threat to *A. varicosa* population integrity.
- Determine fish hosts for species where this is not known for populations living in New York.
- Research population dynamics of listed mussel species including connectivity of populations or subpopulations and genetic distinctness of populations or subpopulations.
- Determine or confirm breeding phenology and habitat conditions necessary for successful breeding for listed mussels (e.g.. mussel density, pop. level of fish host, temp, flow).

Modify regulation:

- Modify marine mussel regulations to be clearer that freshwater mussels are protected under ECL.

New regulation:

- Ban the importation of fish that feed on freshwater mollusks (e.g.. black carp).
- Require inclusion of all stages of freshwater mussels in testing for approval of new pesticides in New York.

Other action:

- Develop an outreach program to private landowners through the Landowner Incentive Program to educate the public about freshwater mussel protection and initiate projects to prevent or repair impacts from land use on mussels.
- Increase regional permit control of development and highway projects that may impact native mussels.
- Develop standard monitoring/survey protocols for development projects in all watersheds in New York.
- Evaluate threats to mussels in each New York watershed and prioritize areas for actions to address the threats.
- Research the best survey methods both for detection of rare species and evaluation of population status and trends.
- Begin evaluation of members of the family Sphaeridae (fingernail clams) for inclusion into the species at risk list.

Population monitoring:

- Conduct population estimates of species-at-risk listed mussel species in NY
- Conduct surveys to determine distribution of species-at-risk listed mussel species in NY.

Regional management plan:

- Incorporate freshwater mussel goals and objectives into regional water quality and fish management plans and policies.

Relocation/reintroduction:

- Where appropriate, reintroduce listed mussels into appropriate habitat within their historic range.

Statewide management plan:

- Incorporate freshwater mussel goals and objectives into statewide water quality and fish management plans and policies.

VII. References

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